The study of higher plant growth in space started in the 1950s both on the Russian and the American sides. The first experiments were intended to assess whether plants could grow outside Earth and to determine what differences there were between spaceflight-grown and Earth-grown plants. As plant-growth hardware started to adapt to spaceflight, more opportunities for plant experiments in space became available. Direct microgravity effects started being differentiated from confinement effects and Earth orbit started to become a laboratory where plants could be grown without the influence of Earth gravity. Experiments have shown that, with adapted ventilation, plant growth in space is similar to plant growth on Earth in 1 g, except for some morphological traits. However, only small-scale experiments on plant growth were performed in Earth orbit, which provided insufficient data on crop yield for reduced gravity environments. Challenges remain to grow plants in space, in terms of nutrient delivery, lighting and ventilation, but also on the choice of plant species and traits to favour. Additionally, significant effort must be made on mechanistic modelling of plant growth to reach a more thorough understanding of the intricate and combined physical, biochemical, and morphological phenomena involved, which is necessary to accurately control and predict plant growth in life-support systems. This review intends to list the main spaceflight effects to take into account for plant growth in space, as well as to give an overview of the current state of plant-growth hardware while stressing the challenges associated with their development.